Express Mail No.: ER224695427US

9-31-05

Correction of Inventorship
37 C.F.R. §1.48(a)

IFW

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of: Colin John Dickinson **Attorney Docket No.:** M02A296
Application Serial No.: 10/750,310 **Group Art Unit:** 3747
Application Filed: December 31, 2003
Title: Method and Apparatus for High Speed Atomic Layer Deposition

COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, VA 22313-1450

CERTIFICATE OF MAILING

I hereby certify that this correspondence and every writing referred to herein as being enclosed is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on Jan 27, 2005 (Date).

Phyllis Servon
Printed name of person signing this certificate

Signature of person mailing

SIR:

CORRECTION OF INVENTORSHIP IN A NONPROVISIONAL APPLICATION AFTER OATH/DECLARATION FILED
37 C.F.R. §1.48(a)

1. This amendment and request is to correct the incorrect original naming of inventor(s) in the declaration under 37 C.F.R. § 1.48(a) as set forth and filed on .

2. Addition and/or Deletion of Inventor(s)

(check and complete all applicable items)

☐ Add the following previously unnamed person(s) as inventor(s) of this application:

Frank Jansen

☐ Delete the following previously incorrectly named inventor(s):

02/04/2005 BABRAHA1 00000036 022865 10750310
01 FC:1464 130.00 DA

3. Attachments: Attached is

(a) A statement from: *(check items below that apply)*

- ☐ each person being added as an inventor that the error in inventorship occurred without deceptive intention on his or her part. 37 C.F.R. § 1.48(a)(1).
- ☐ each person being deleted as an inventor that the error in inventorship occurred without deceptive intention on his or her part. 37 C.F.R. § 1.48(a)(1).

(b) A declaration by each of the actual inventor(s) as required by 37 C.F.R. § 1.63 (or as permitted by §§ 1.42, 1.43, OR 1.47). 37 C.F.R. § 1.48(a)(2).

(c) A written assent of the assignee *(if any of the original inventors executed an assignment)* 37 C.F.R. 1.48(a)(4)

(d) *(check the following item, if all the inventor(s) remaining, after this petition and amendment is accepted, are not the inventor(s) of the subject matter of all the claim(s) now being claimed.)*

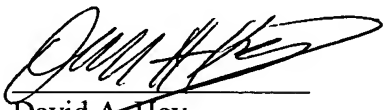
- ☐ Attached is an explanation of the facts, including the ownership of all the claim(s) being claimed in this application, including the ownership of all the claim(s) at the time the last claimed invention was made (Declaration of Inventorship and Common Ownership of Claims in Application).

4. Fee Payment (37 C.F.R. § 1 .17(i)-$130.00)
The fee required is paid as follows:

☐ Attached is a ? check ? money order in the amount of $ _____

- ☐ Authorization is hereby made to charge the amount of $ 130.00.
- ☐ to Deposit Account No. 02-2865.
- ☐ to Credit card as shown on the attached credit card information authorization form PTO-2038.
- ☐ Charge any additional fees required by this paper or credit any overpayment in the manner authorized above. A duplicate of this paper is attached.

Respectfully submitted,



Date: January 27, 2005

David A. Hey
Attorney of Record
Registration No. 32,351
TEL: (908) 771-6385
FAX:(908) 771-6167

The BOC Group, Inc.
Legal Services-IP Dept.
575 Mountain Avenue
Murray Hill, NJ 07974

Express Mail No.: ER224695427US

Correction of Inventorship
37 C.F.R. §1.48(a)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In patent application of: Colin John Dickinson **Attorney Docket No.:** M02A296

Application Serial No.: 10/750,310 **Group Art Unit:** 3747

Application Filed: December 31, 2003

Title: METHOD AND APPARATUS FOR HIGH SPEED ATOMIC LAYER DEPOSITION

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(Date)

Phyllis Servon
Printed name of person signing this certificate

Phyllis Servon
Signature of person mailing

SIR:

ASSENT OF ASSIGNEE TO CORRECTION AND/OR ADDITION OF INVENTOR(S)

Frank Jansen
(type or print name of assignee)
1077 Noble Lane
Address
San Jose, California 95132

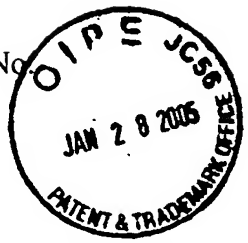
Assignment

☐ recorded on: August 11, 2004
Reel 015007
Frame 0678

☐ recorded herewith

☐ A separate "ASSIGNMENT" (DOCUMENT) COVER SHEET is attached.

Application No.
10/750,310



Correction of Inventorship
37 C.F.R. §1.48(a)

- FORM PTO 1595 is attached.

☐ Assignee hereby assents to the correction of inventorship filed herewith.

on _____.

Respectfully submitted,

Date: January 27, 2005

David A. Hey
Attorney of Record
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TEL: (908) 771-6385
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Correction of Inventorship
37 C.F.R. §1.48(a)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of: Colin John Dickinson **Attorney Docket No.:** M02A296

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Phyllis Servon
Printed name of person signing this certificate

Phyllis Servon
Signature of person mailing

SIR:

STATEMENT FROM INVENTOR BEING ADDED
37 C.F.R. §1.48(a)(2)

I, Frank Jansen, PhD., Vice President of Engineering of The BOC Group's BOC Edwards division and co-inventor of Application No. 10/750,310, hereby state that the error in inventorship of the Application as filed occurred without deceptive intention on my part.

Frank Jansen
Signature

Frank Jansen, PhD
Print Name

November 22, 2004
Date

Express Mail No.: ER224695427US

PTO/SB/17i (11-04)
Approved for use through 07/31/2007. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PROCESSING FEE
Under 37 CFR 1.17(i)
TRANSMITTAL

(Fees are subject to annual revision)

Send completed form to: Commissioner for Patents
P.O. Box 1450, Alexandria, VA 22313-1450

Application Number	10/750,310
Filing Date	December 31, 2003
First Named Inventor	Dickinson
Art Unit	3747
Examiner Name	
Attorney Docket Number	M02A296

Enclosed is a paper filed under 37 CFR 1.48(a) **that requires a processing fee (37 CFR 1.17(i)).**
Payment of $ 130.00 **is enclosed.**

This form should be included with the above-mentioned paper and faxed or mailed to the Office using the appropriate Mail Stop, if applicable. *For transmittal of petition fees under 37 CFR 1.17(f), (g) or (h), see form PTO/SB/17p.*

Payment of Fees (small entity amounts are NOT available for the petition fees)

[X] The Commissioner is hereby authorized to charge the following fees to Deposit Account No. 02-2865:
[X] processing fee under 37 CFR 1.17(i) [X] any deficiency of fees and credit of any overpayments
Enclose a duplicative copy of this form for fee processing.

[ ] Check in the amount of $_____ is enclosed.

[ ] Payment by credit card (Form PTO-2038 or equivalent enclosed). Do not provide credit card information on this form.

Processing Fees under 37 CFR 1.17(i): Fee $130 Fee Code 1808 for all,
Except for § 1.221 papers (Fee Code 1803)

For papers filed under:
§ 1.28(c)(3) - for processing a non-itemized fee deficiency based on an error in small entity status.
§ 1.41 - for supplying the name or names of the inventor or inventors after the filing date without an oath or declaration as prescribed by § 1.63, except in provisional applications.
§ 1.48 - for correcting inventorship, except in provisional applications.
§ 1.52(d) - for processing a nonprovisional application filed with a specification in a language other than English.
§ 1.53(b)(3) - to convert a provisional application filed under § 1.53(c) into a nonprovisional application under § 1.53(b).
§ 1.55 - for entry of late priority papers.
§ 1.99(e) - for processing a belated submission under § 1.99.
§ 1.103(b) - for requesting limited suspension of action, continued prosecution application (§ 1.53(d)).
§ 1.103(c) - for requesting limited suspension of action, request for continued examination (§ 1.114).
§ 1.103(d) - for requesting deferred examination of an application.
§ 1.217 - for processing a redacted copy of a paper submitted in the file of an application in which a redacted copy was submitted for the patent application publication.
§ 1.221 - for requesting voluntary publication or republication of an application. **Fee Code 1803**
§ 1.291(c)(5) - for processing a second or subsequent protest by the same real party in interest.
§ 1.497(d) - for filing an oath or declaration pursuant to 35 U.S.C. 371(c)(4) naming an inventive entity different from the inventive entity set forth in the international stage.
§ 3.81 - for a patent to issue to assignee, assignment submitted after payment of the issue fee.

Signature

January 27, 2005
Date

David A. Hey
Typed or printed name

32,351
Registration No., if applicable

>

II. < 37 CFR 1.48(a)

37 CFR 1.48. Correction of inventorship in a patent application, other than a reissue application, pursuant to 35. U.S.C. 116.

(a) *Nonprovisional application after oath/declaration filed.* If the inventive entity is set forth in error in an executed § 1.63 oath or declaration in a nonprovisional application, and such error arose without any deceptive intention on the part of the person named as an inventor in error or on the part of the person who through error was not named as an inventor, the inventorship of the nonprovisional application may be amended to name only the actual inventor or inventors. If the nonprovisional application is involved in an interference, the amendment must comply with the requirements of this section and must be accompanied by a motion under § 1.634. Amendment of the inventorship requires:

(1) A request to correct the inventorship that sets forth the desired inventorship change:

(2) A statement from each person being added as an inventor and from each person being deleted as an inventor that the error in inventorship occurred without deceptive intention on his or her part:

(3) An oath or declaration by the actual inventor or inventors as required by § 1.63 or as permitted by §§ 1.42, 1.43 or § 1.47:

(4) The processing fee set forth in § 1.17(i): and

(5) If an assignment has been executed by any of the original named inventors, the written consent of the assignee (see § 3.73(b) of this chapter).

*****

Under 37 CFR 1.48(a), if the correct inventor or inventors are not named in an executed oath or declaration under 37 CFR 1.63 in a nonprovisional application for patent, the application can be amended to name only the actual inventor or inventors so long as the error in the naming of the inventor or inventors occurred without any deceptive intention on the part of the person named as an inventor in error or the person who through error was not named as an inventor.

37 CFR 1.48(a) requires that the amendment be accompanied by: (1) a request to correct the inventorship that sets forth the desired inventorship change; (2) a statement from each person being added and from each person being deleted as an inventor that the error occurred without deceptive intention on his or her part; (3) an oath or declaration by each actual inventor or inventors as required by 37 CFR 1.63 or as permitted by 37 CFR 1.42, 1.43 or 1.47; (4) the fee set forth in 37 CFR 1.17 (i): and (5) the written consent of any existing assignee, if any of the originally named inventors has executed an assignment.

Correction may be requested in cases where the person originally named as inventor was in fact not an inventor or the sole inventor of the subject matter being claimed. If such error occurred without any deceptive intention on the part of the inventor named and/or not named in error, the Office has the authority to substitute the true inventive entity for the erroneously named inventive entity. Instances where corrections can be made include changes from: a mistaken sole inventor to a different but actual sole inventor; a mistakenly identified sole inventor to different, but actual, joint inventors; a sole inventor to joint inventors to include the original sole inventor; erroneously identified joint inventors to different but actual joint inventors; erroneously identified joint inventors to a different, but actual, sole inventor. (Note that 35 U.S.C. 120 and 37 CFR 1.78 require an overlap of inventorship, hence, refiling, rather than requesting under 37 CFR 1.48, to change inventorship where the change would not result in an inventorship overlap may result in the loss of a priority claim.)

A. Statement of Lack of Deceptive Intention

Where a similar inventorship error has occurred in more than one application for which correction is requested wherein petitioner seeks to rely on identical statements, only one original set need be supplied if copies are submitted in all other applications with a reference to the application containing the originals (original oaths or declarations under 37 CFR 1.63 and written consent of assignees along with separate processing fees must be filed in each application).

The statement required from each inventor being added or deleted may simply state that the inventorship error occurred without deceptive intention. The statement need not be a verified statement (see MPEP § *>410<).

On very infrequent occasions, the requirements of 37 CFR 1.48(a) have been waived upon the filing of a request and fee under 37 CFR 1.183 (along with the request and fee under 37 CFR 1.48(a)) to permit the filing of a statement by less than all the parties required to submit a statement. *In re Cooper*, 230 USPQ 638, 639 (Dep. Assist. Comm'r Pat. 1986). However, such a waiver will not be considered unless the facts of record unequivocally support the correc-

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PTO/SB/01A (08-03)
Approved for use through 06/30/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	METHOD AND APPARATUS FOR HIGH SPEED ATOMIC LAYER DEPOSITION M02A296

As the below named inventor(s), I/we declare that:

This declaration is directed to:

☑ The attached application, or

☑ Application No. 10/750,310, filed on December 31, 2003,

☐ as amended on _____(if applicable);

I/we believe that I/we am/are the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought;

I/we have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above;

I/we acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me/us to be material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT International filing date of the continuation-in-part application.

All statements made herein of my/own knowledge are true, all statements made herein on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

FULL NAME OF INVENTOR(S)

Inventor one: Frank Jansen

Signature: Frank Jansen Citizen of: NETHERLANDS

Inventor two: _____

Signature: _____ Citizen of: _____

Inventor three: _____

Signature: _____ Citizen of: _____

Inventor four: _____

Signature: _____ Citizen of: _____

☐ Additional inventors or a legal representative are being named on _____ additional form(s) attached hereto.

PATENT
ATTY. DKT. M02A296

EXPRESS MAIL MAILING LABEL: ER 688408045 US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

NEW PATENT APPLICATION

METHOD AND APPARATUS FOR HIGH SPEED ATOMIC LAYER DEPOSITION

Inventor: Colin John Dickinson

METHOD AND APPARATUS FOR HIGH SPEED ATOMIC LAYER DEPOSITION

Background of the Invention

[0001] This invention is directed to atomic layer deposition. More particularly this invention provides an apparatus and process in which precursor gases including the species used to form monatomic layers can be quickly alternated so as to allow the atomic layer deposition process to be conducted with fast cycle time.

[0002] Atomic layer deposition is a method of depositing very thin films onto a surface. Individual precursor gases are pulsed onto the surface, typically a wafer, in a sequential manner without mixing the precursors in the gas phase. Each precursor gas reacts with the surface to form an atomic layer in a way such that only one layer at a time can be deposited onto the surface.

[0003] In order to avoid clogging and reaction of the precursor gases in areas other than the desired surface, inert gases such as argon and nitrogen are used as purge gases between application of different precursor gases. For example, Si_2Cl_6 and NH_3, $TiCl_4$ and NH_3, Si_2Cl_6 and activated NH_3 are commonly used precursors.

[0004] Unfortunately, interruption of flow of a precursor gas in order to allow introduction of another precursor gas can result in condensation related problems especially when using unstable precursors.

[0005] Accordingly, there is a need for an atomic layer deposition arrangement and process which reduces condensation, avoids clogging and reaction of the precursor gases in areas other than the desired surface, minimizes gas turbulence and provides fast cycle time.

Summary of the Invention

[0006] It is an object of the invention to provide an atomic layer deposition arrangement and process which avoids undesirable condensation of precursor gases.

[0007] Another object of the invention is to provide an atomic layer deposition arrangement and process which allows fast cycle times for precursor gases.

[0008] A further object of the invention is to provide an atomic layer deposition arrangement and process which provides steady flow of precursor gases.

[0009] An additional object of the invention is to provide an atomic layer deposition arrangement and process which provides for reduced use of a purge gas between pulses of precursor gases.

[00010] Another object of the invention is to provide an atomic layer deposition process and apparatus which provides fast evacuation of precursor gases from the process chamber.

[00011] These and other objects of the invention are provided by an atomic layer deposition arrangement comprising a process reactor chamber including an inlet for receiving precursor gases and at least one outlet coupled through an outlet line to an exhaust pump, a first precursor gas valve which receives a first precursor gas and second precursor gas valve which receives a second precursor gas. The first precursor gas valve and second precursor gas valve are coupled to the inlet of the process reactor chamber. A first bypass conduit coupled to the first precursor valve and a second bypass conduit coupled to the second precursor valve allows steady flow of the precursor gases in between delivery to the process

reactor chamber. The first bypass conduit and second bypass conduit are isolated from the outlet line. The outlet line coupled to the exhaust pump allows fast evacuation of the process reactor chamber.

[00012] The invention also provides a method for delivering precursor gas to an atomic layer deposition chamber comprising introducing a substrate into a process reactor chamber having a chamber inlet and a chamber outlet, reducing pressure in the chamber, flowing a first precursor gas to an inlet of a bypass position of a first gas valve, the first gas valve including a chamber delivery position coupled to the chamber inlet, switching the first gas valve to the chamber delivery position to convey the first precursor gas from the gas valve to the chamber inlet, switching the first gas valve to the inlet of the bypass position of the first gas valve, reducing pressure in the chamber, flowing a second precursor gas to the inlet of a bypass position of a second gas valve, the second gas valve including a chamber delivery position coupled to the chamber inlet, switching the second gas valve to a chamber delivery position to convey the second precursor gas from the second gas valve to the chamber inlet, and switching the second gas valve to the inlet of the bypass position of the second gas valve wherein the second precursor gas is conveyed to the chamber inlet without previously purging the chamber with a purge gas.

Brief Description of the Drawings

[00013] Fig. 1 is a schematic illustration of an atomic layer deposition arrangement in accordance with the invention;

[00014] Fig. 2 is a schematic illustration of an atomic layer deposition arrangement including two way valves in accordance with the invention,

[00015] Fig. 3 is a partial cross-section view of a substrate receiving mechanism within the process chamber reactor;

Fig. 4 is a schematic illustration of an atomic layer deposition arrangement including a purge has system in accordance with the invention; and

Fig. 5 is a schematic illustration of an atomic layer deposition arrangement including two way valves to meter the precursor gases in accordance with the invention.

Detailed Description of The Preferred Embodiments

[00016] A schematic illustration of an atomic layer deposition arrangement in accordance with the invention is shown in Figure 1.

[00017] The atomic layer deposition system includes a process reactor chamber 10 including an inlet 12 for receiving precursor gases. A process reactor chamber outlet 14 is coupled through an outlet line 16 to an exhaust pump 18. The exhaust pump may be any suitably sized vacuum pump, such as the EPX 180L Dry Pump available from BOC Edwards. A first precursor gas valve 20 receives a first precursor gas A and a second precursor valve 22 receives a second precursor gas B. A first bypass conduit 24 is coupled to first precursor valve 20 and a second bypass conduit 26 is coupled to second precursor valve 22. As can be seen from Fig. 1, first bypass conduit 24 and second bypass conduit 26 are isolated from outlet line 16.

[00018] In an alternate embodiment, two sets of two way valves 45 can be used instead of a three way valve as shown in Figure 2.

[00019] In a typical atomic layer deposition process, a substrate is introduced into the process reactor chamber 10 through an opening, which is selectively closed through gate valve 30. The substrate may be for example, a processed semiconductor wafer, an unprocessed semiconductor wafer or a substrate intended for a flat panel display and/or any other type of substrate. A vacuum hold down is applied to the platen 32 by opening vacuum valve 34. The exhaust pump 18 is in flow communication with the chamber 10. Vacuum valves 34, 35 are arranged in direct communication with the chamber 10 and a vacuum hold down system 40. The vacuum hold down system 40 is configured to hold the substrate onto platen 32 during movement of the platen 32. Vacuum valve 42 may be in flow communication with the chamber 10 through the sub-chamber 44. A plurality of vacuum gauges 36, 38 may be provided to monitor the rate of evacuation of the chamber 10 through the vacuum valves 34, 35 and 42.

[00020] A check valve 46 may be associated with the gas flow path downstream from exhaust valve 48 to prevent back flow of gas while the exhaust valve 48 is open in the event the chamber 10 is under pressurized. The vacuum pump 18 is connected to a vent 50.

[00021] A more detailed view of the platen 32 is shown in Figure 3. The platen 32 is attached to a movement mechanism 52 which may be a linear actuator, a hydraulic piston, a pneumatic piston, or any other mechanism suitable for linear motion to the platen 32. The platen 32 has at least one through hole 100 formed therein. The platen 32 also has a first hollow shaft portion 102 and a second hollow shaft portion 104 in flow communication with the through hole 100 in the platen. A port member 106 is inserted into vacuum outlet 40, which is in flow communication with the hollow shaft portion 102. The other end of the port member 106 is in flow communication with the vacuum pump 18, shown in Fig. 1. The

structure 122 forming a flow path placing the through hole 100 in flow communication with the vacuum pump 18 forms a vacuum hold down that secures the object to the surface of the platen 32. A plurality of raised portions 124 assist in distributing vacuum force to the surface of the platen and thereby aid in securing an object to the platen 32.

[00022] The end of the hollow shaft portion 102 opposite the platen 32 is attached to a movement mechanism 52 which may be a linear actuator, a hydraulic piston, a pneumatic piston, or any other mechanism suitable for providing linear motion to the platen 32.

[00023] The movement mechanism 52 is arranged within a support member 110 affixed to the sub-chamber 44. The sub-chamber 44 may be fastened to the chamber 10 of Fig. 1 via one or more through holes 114 (only one of which is shown). This arrangement allows the platen 32 to be raised and lowered in relation to the sub-chamber 44 and the interior of the chamber 10. A steel bellows 116 is also contained within the sub-chamber 44 to cooperate with a radically extending flange portion 118 on the hollow shaft portion 102 to seal the sub-chamber 44 around the hollow shaft portion 104.

[00024] The sub-chamber 44 includes an outlet 14 (e.g., exhaust port) that provides flow communication between the interior of the chamber 10 of Fig. 1 and vacuum pump 18. The outlet 14 and outlet line 16 define an exhaust flow path that may be connected to both the vacuum pump 18 and the exhaust valve 48, shown in Fig. 1, to provide vacuum flow in the exhaust flow path.

[00025] The platen 32 is arranged above the outlet 14 and is movable in the interior of the chamber 10 so as to adjust conductance of the exhaust flow from the interior of the chamber 10 to the exhaust flow path via the outlet 14. For example, the platen 32 can be

raised and lowered to vary the distance H between a lower surface 126 of the platen and the upper surface 128 of the sub-chamber 44. Varying the distance H controls the rate at which gas is withdrawn from the chamber 10 during placement of the chamber into vacuum condition and varies the conductance between the platen 32 and the sub-chamber 44 through the outlet 14. This object receiving mechanism 130 is configured to increase throttling of gas being withdrawn when the object receiving mechanism 130 is in a lowered position and to decrease the throttling when the object receiving mechanism 130 is in a raised positioned. This may prevent damage to the object 28 during the gas evacuation process. In addition, by raising the object receiving mechanism 130, the conductance is increased and by lowering the object receiving mechanism 130, the conductance is decreased.

[00026] By monitoring the vacuum gauges 36, 38, shown in Fig. 1, it is possible to control the movement mechanism 52 to vary the distance H and thereby adjust the flow rate of withdrawn gas. Alternatively, without relying on the vacuum gages 36, 38, the positioning and movement of the platen 32 over a period of time could be predetermined to adjust the flow rate accordingly. Both approaches may be accomplished by configuring a controller, not shown, to control the movement of the object receiving mechanism 130 to adjust the throttling of the exhaust flow from the interior of the chamber 10 based on the position of the object receiving mechanism 130 or data from the vacuum gages 36, 38. In this manner platen position can be adjusted to provide necessary conductance for the chamber to be evacuated in a suitable time frame without causing particle stirring within the chamber.

[00027] During the chamber evacuation valves 20 and 22 are in bypass mode so that steady gas conditions are achieved for precursor gas species A and B.

[00028] Once an appropriate reduced pressure is achieved, the movement mechanism 52 is moved downwards to create minimum conductance to the vacuum pump 18. The 3 way valve 20 is then switched to allow flow of vapor/gas species A to the chamber 10 to deposit a monatomic layer onto the substrate. During this process the chamber pressure will rise to around atmospheric pressure. The valve 20 is then switched to bypass and the movement mechanism 52 moves upward to allow evacuation of the chamber 10 to remove vapor/gas species A. After a reduced pressure is obtained, the movement mechanism 52 moves downward to provide the minimum conductance to the vacuum pump and valve 22 is switched to allow flow of vapor/gas species B to the chamber 10 to deposit a monatomic layer onto the substrate.

[00029] The above process is repeated to provide sequential deposition of a plurality of layers of A and B until the desired deposition thickness is achieved. Each species/layer can be deposited in a 1-2 second cycle time.

[00030] On completion of the deposition process isolation valve 48 is opened, valve 42 is closed and valve 35 is opened to allow the wafer vacuum hold down to be released. The gate valve 30 is then opened to allow the substrate to be removed from the chamber.

[00031] The process chamber 10 may be connected to a conventional vacuum cluster central handler or alternatively connected to an atmospheric robot handling system. This allows atomic layer deposition processes to be integrated to any configuration of wafer processing architecture.

[00032] An alternate embodiment including a purge gas system is shown in Figure 4. In between introduction of precursor gas A and precursor gas B to the process reactor, a purge gas, for example, nitrogen or argon, is introduced into the process reactor chamber 10.

Each of valve 20 and 22 are in bypass mode as the purge gas flows into process chamber 10 through valve 200. The purge gas flows through process reactor chamber 10 to the vacuum pump. Preferably, the purge gas is introduced into process reactor chamber 10 at a pressure of 5 standard (std) liters per minute for less than 5 seconds duration, more preferably 1 standard (std) liter per minute for less than 2 seconds duration. Unlike conventional systems, in which a full dose of purge gas is introduced into the process chamber at a pressure of 10 std liters per minute for 5 to 10 seconds, the purge process is substantially reduced. In this manner, the invention provides for fast cycle times.

[00033] An embodiment including a purge gas system wherein the precursor gases are metered using two way valves is shown in Figure 5. The two sets of two way valves 210 and 220 control the flow of precursor gas A and precursor gas B.

[00034] Although preferred embodiments are specifically illustrated and described herein above, it will be appreciated that many modifications and variations of the present invention are possible in light of the above teachings and within the preview of the appended claims without departing from the spirit and intended scope of the invention.

We claim:

1. An atomic layer deposition arrangement comprising:

a process reactor chamber including an inlet for receiving precursor gases and at least one outlet coupled through an outlet line to an exhaust pump,

a first precursor gas valve which receives a first precursor gas, said first precursor gas valve coupled to said inlet,

a second precursor gas valve which receives a second precursor gas, said second precursor gas valve coupled to said inlet,

a first bypass conduit coupled to said first precursor valve,

a second bypass conduit coupled to said second precursor valve, and

wherein said first bypass conduit and said second bypass conduit are isolated from the outlet line.

2. An atomic layer deposition arrangement according to claim 1 wherein the first precursor gas valve and second precursor gas valve are each three way valves.

3. An atomic layer deposition arrangement according to claim 1 wherein the first precursor gas valve and second precursor gas valve each include two two-way valves.

4. An atomic layer deposition arrangement according to claim 1 wherein the first bypass conduit and the second bypass conduit are isolated from each other.

5. An atomic layer deposition arrangement according to claim 1 further comprising a substrate holding device located in the process chamber, the substrate holding device movable in a longitudinal direction.

6. An atomic layer deposition arrangement according to claim 1 wherein the chamber includes a sub-chamber and wherein the at least one outlet is located in the sub-chamber.

7. An atomic layer deposition arrangement according to claim 5 wherein the substrate holding device comprises a vacuum hold down system.

8. An atomic layer deposition arrangement according to claim 7 wherein the vacuum hold down system includes a hollow shaft connected to a plate member having at least one through hole.

9. An atomic layer deposition arrangement according to claim 1 further comprising a valve which receives a purge gas, said valve coupled to the inlet to the process reactor chamber.

10. A method for delivering precursor gas to an atomic layer deposition chamber comprising:

placing a substrate onto a substrate holding device in a process reactor chamber having a chamber inlet and chamber outlet,

isolating the chamber by closing a gate valve,

reducing pressure in the chamber by moving the substrate holding device upward in a longitudinal direction to provide a high conductance connection between the chamber and the vacuum pump,

isolating the chamber from the vacuum pump by moving the substrate holding device downward in a longitudinal direction to provide a minimum conductance connection between the chamber and a vacuum pump,

flowing a first precursor gas to an inlet of a bypass position of a first gas valve, the first gas valve including a chamber delivery position coupled to the chamber inlet,

switching said first gas valve to the chamber delivery position to convey the first precursor gas from the gas valve to the chamber inlet,

switching said first gas valve to the inlet of the bypass position of the first gas valve,

reducing pressure in the chamber by moving the position of the substrate holding device upward in a longitudinal direction to provide a high conductance connection between the chamber and a vacuum pump,

isolating the chamber from the vacuum pump by moving the substrate holding device downward in a longitudinal direction to provide a minimum conductance connection between the chamber and a vacuum pump,

flowing a second precursor gas to the inlet of a bypass position of a second gas valve, the second gas valve including a chamber delivery position coupled to the chamber inlet,

switching said second gas valve to a chamber delivery position to convey the second precursor gas from the second gas valve to the chamber inlet,

switching said second gas valve to the inlet of the bypass position of the second gas valve,

wherein said second precursor gas is conveyed to the chamber inlet without previously purging the chamber with a full dose of purge gas.

11. A method for delivering precursor gas to an atomic layer deposition chamber according to claim 5 wherein the first precursor gas valve and second precursor gas valve are each three way valves.

12. A method for delivering precursor gas to an atomic layer deposition chamber according to claim 5 wherein the first precursor gas valve and second precursor gas valve each include two two-way valves.

13. A method for delivering precursor gas to an atomic layer deposition chamber comprising:

placing a substrate onto a substrate holding device in a process reactor chamber having a chamber inlet and chamber outlet,

isolating the chamber by closing a gate valve,

reducing pressure in the chamber by moving the substrate holding device upward in a longitudinal direction to provide a high conductance connection between the chamber and a vacuum pump,

isolating the chamber from the vacuum pump by moving the substrate holding device downward in a longitudinal direction to provide a minimum conductance connection between the chamber and the vacuum pump,

flowing a first precursor gas to an inlet of a bypass position of a first gas valve, the first gas valve including a chamber delivery position coupled to the chambers inlet,

switching said first gas valve to the chamber delivery position to convey the first precursor gas from the gas valve to the chamber inlet,

switching said first gas valve to the inlet of the bypass position of the first gas valve,

reducing the pressure in the chamber by moving the substrate holding device upward in a longitudinal direction to provide a high conductance connection between the chamber and a vacuum pump,

flowing a purge gas into the chamber inlet to flush the residual said first gas from the chamber wherein the purge gas is flowed through the chamber in an amount less than a full dose of purge gas,

reducing the pressure in the chamber by moving the position of the substrate holding device upward in a longitudinal direction to provide a high conductance connection between the chamber and a vacuum pump,

isolating the chamber from the vacuum pump by moving the substrate holding device downward in a longitudinal direction to provide a minimum conductance connection between the chamber and a vacuum pump,

flowing a second precursor gas to the inlet of a bypass of a second gas valve, the second gas valve including a chamber delivery position coupled to the chamber inlet,

switching said second gas valve to a chamber delivery position to convey the second precursor gas from the second gas valve to the chamber inlet,

switching said second gas valve to the inlet of the bypass position of the second gas valve, and

flowing a purge gas into the chamber inlet at a pressure to flush the residual said second gas from the chamber.

14. A method according to claim 13 wherein the purge gas is selected from the group consisting of nitrogen and argon.

15. A method according to claim 13 wherein the first precursor gas and second precursor gas valve are each three-way valves.

16. A method according to claim 10 wherein the first precursor gas is selected from the group consisting of Si_2Cl_6 and $TiCl_4$.

17. A method according to claim 10 wherein the second precursor gas is selected from the group consisting of NH_3 and activated NH_3.

18. A method according to claim 13 wherein the first precursor gas is selected from the group consisting of Si_2Cl_6 and $TiCl_4$.

19. A method according to claim 13 wherein the second precursor gas is selected from the group consisting of NH_3 and activated NH_3.

20. A method according to claim 14 wherein the first and second precursor gas are selected from the group consisting of Si_2Cl_6 and NH_3, $TiCl_4$ and NH_3, and Si_2Cl_6 and activated NH_3.

21. A method according to claim 13 comprising flowing the purge gas into the chamber inlet at a flow rate up to 1 standard liter per minute for less than than 2 seconds.

Abstract of the Disclosure

[00035] An atomic layer deposition process is described in which precursor gases including species used to form monatomic layers are quickly alternated as to allow the atomic layer deposition process to be conducted with fast cycle time.

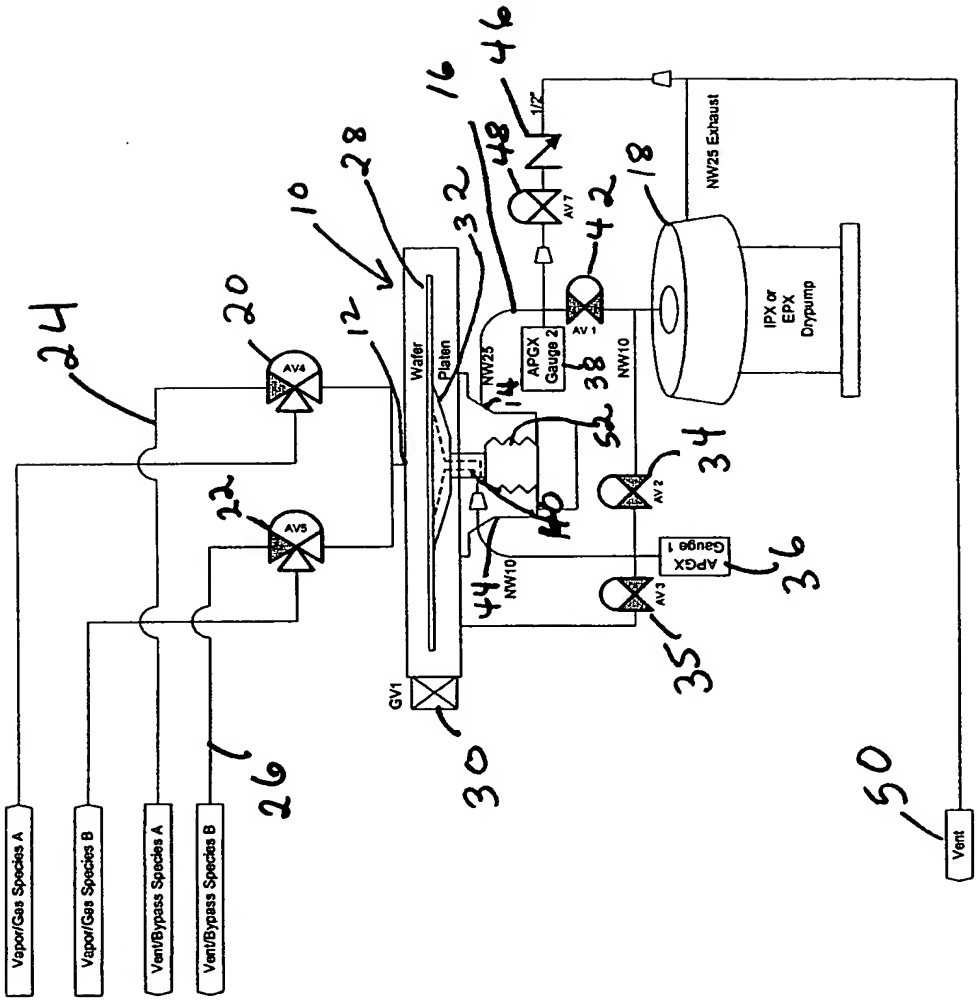

Fig 1

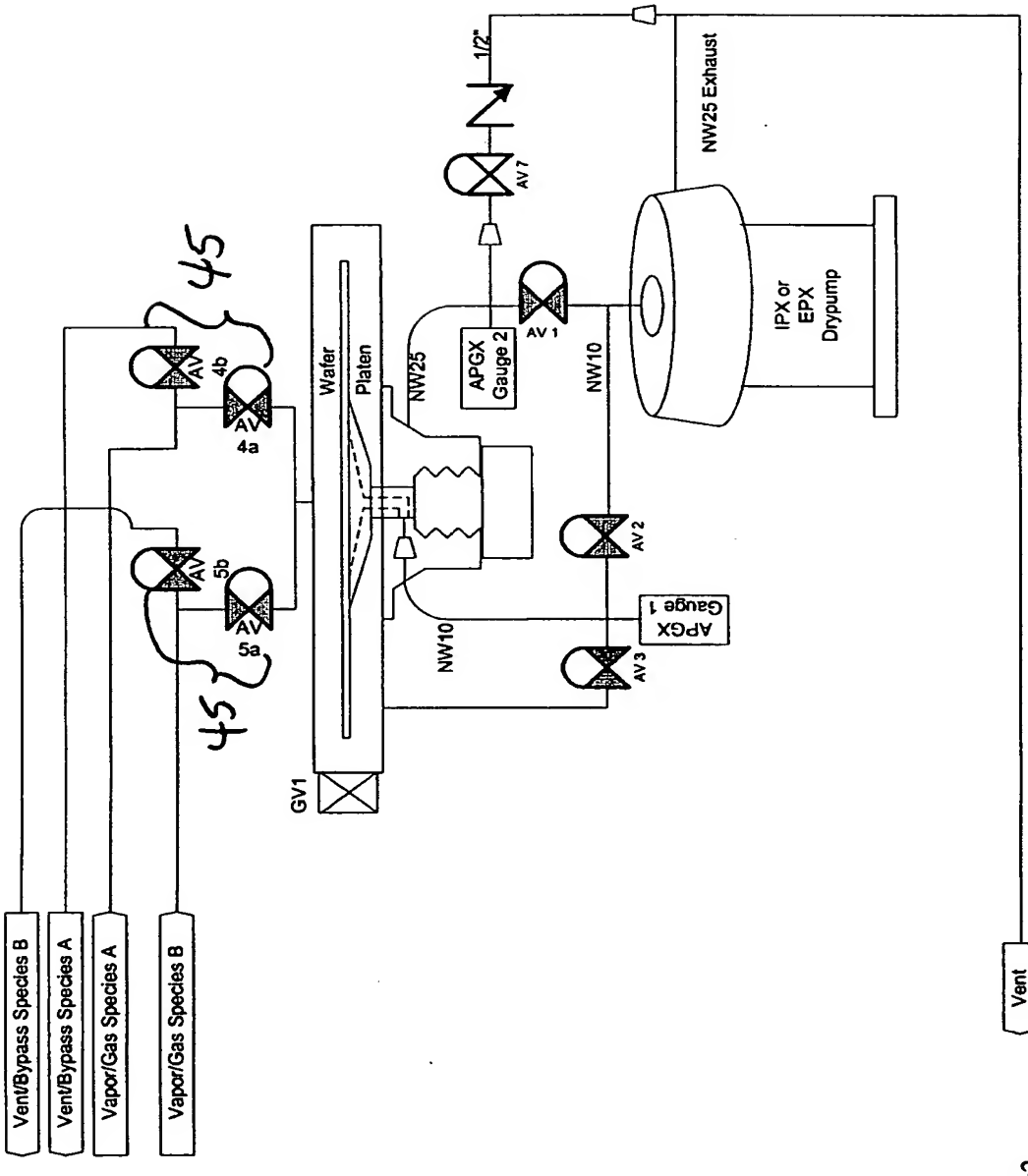

Fig2

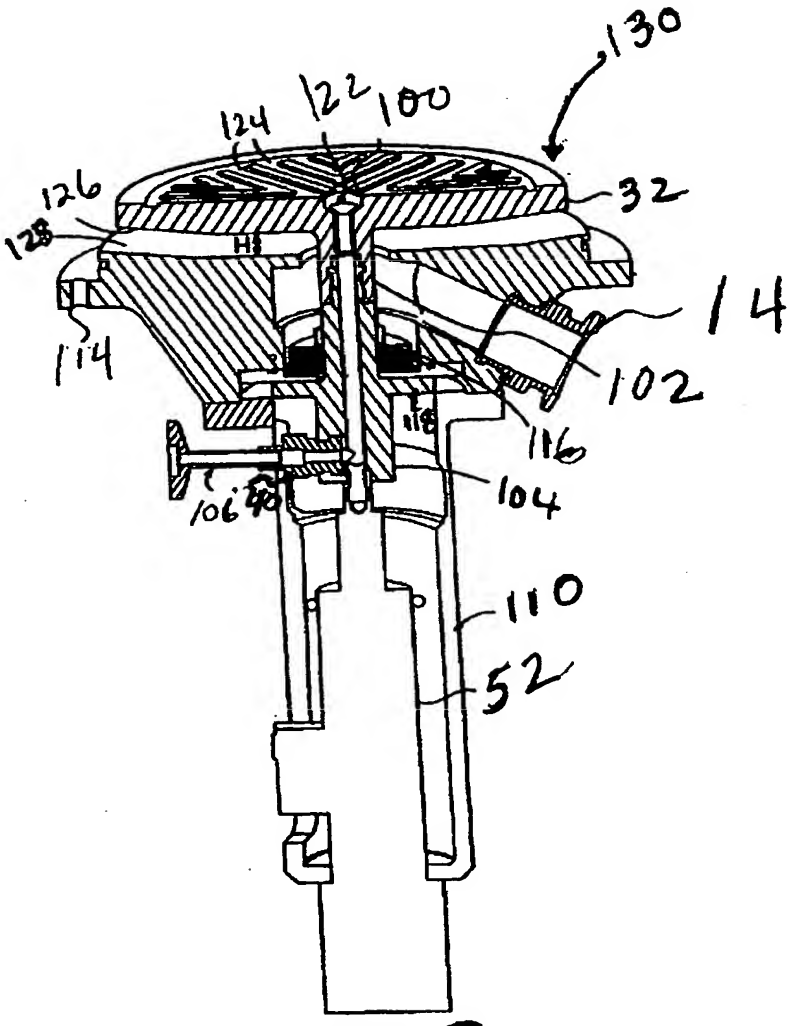

FIG. 3

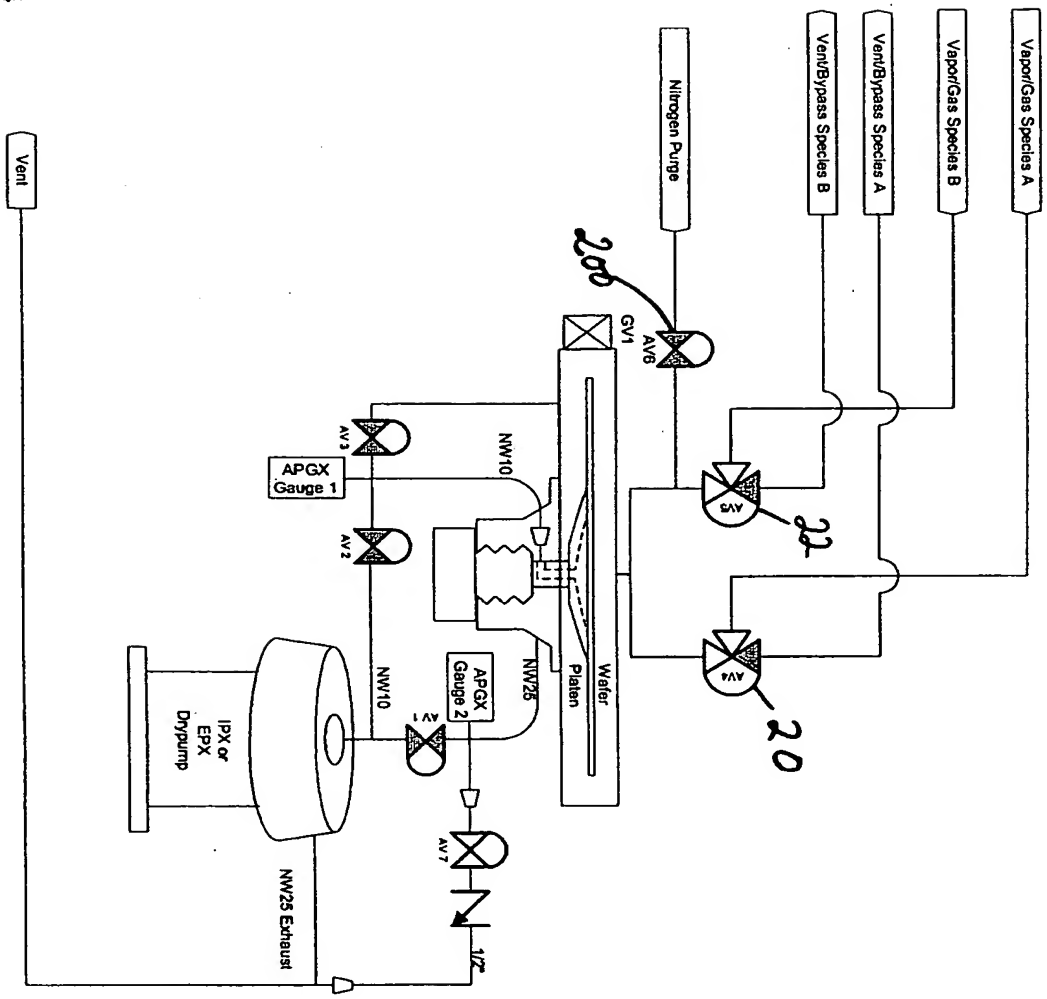

Fig 4

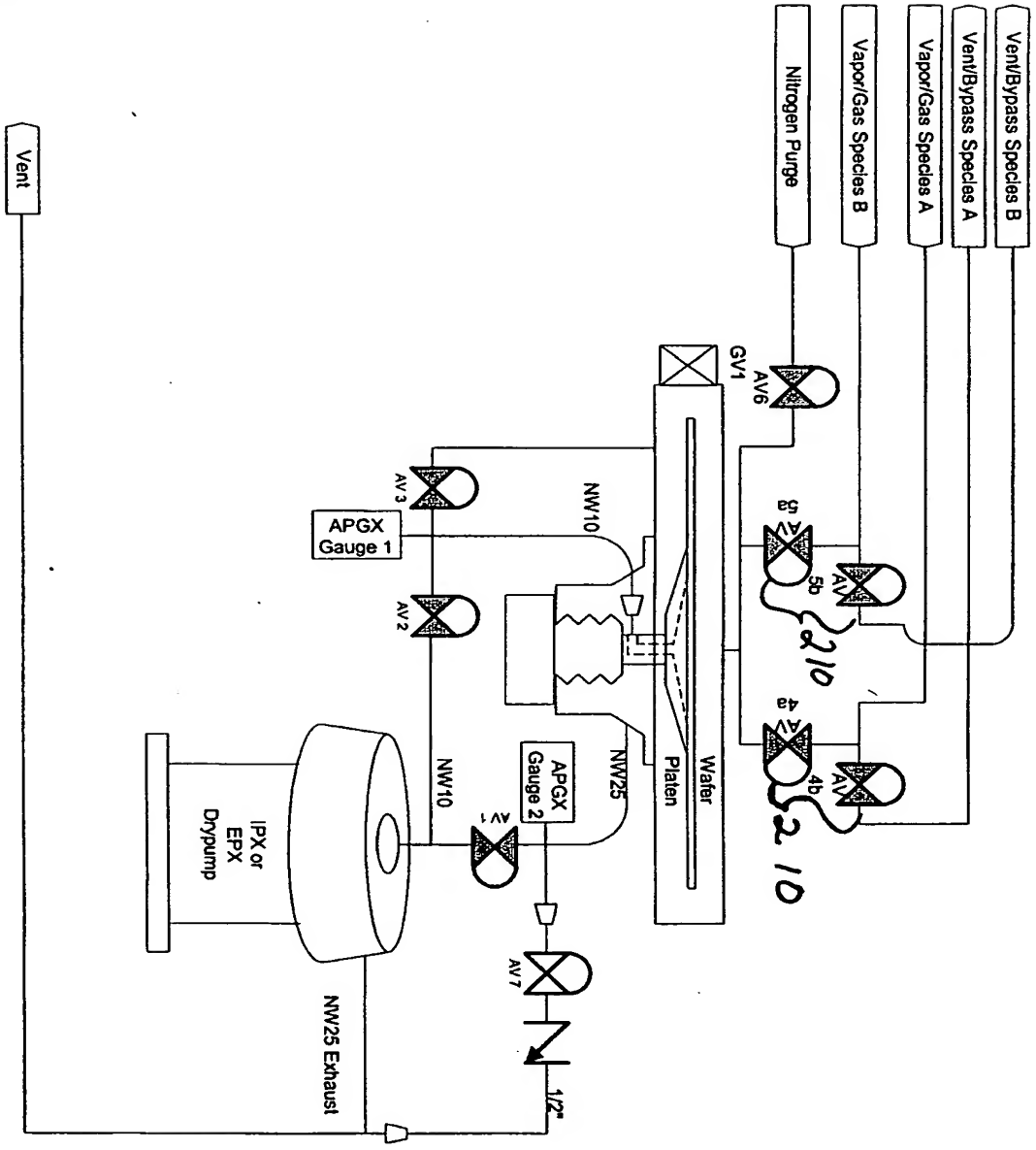

Fig5